Creating Children's Books and Learning Mathematics

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The Principles and Standards for School Mathematics *(NCTM, 2000) describes a guide for high-quality mathematics teaching and learning. The mathematical knowledge that early-grade teachers need to possess; while not sophisticated mathematics, must be meaningful, flexible, and secure. Early childhood teachers need to be able to present mathematical ideas in a variety of contexts and to ask questions about the imbedded mathematics. To develop these capabilities and provide evidence of their mathematical knowledge, I had preservice teachers (PSTs) write letters, create children's books with accompanying "Notes to the Reader" and share their books with first-grade pen pals. This paper lays out the expectations of the instructor for the PSTs, the relationship developed between the pen pal pairs, examples of book pages as well as material written for the reader or teacher to use to enhance the learning experience for children, and the kinds of learning the PSTs took away from the experience.*

Connecting Mathematics Learning with Teaching

During the first year of college, early childhood education students have little opportunity to investigate the wisdom of their career choice. In addition, they have little sense of what they need to know mathematically to teach young children beyond their own basic mathematics skills. Many are quite surprised to find that their Mathematics for Prospective Early Childhood Teachers courses require them to engage deeply with the content in a way with which they have no experience. This adds to the already existing anxiety many of them feel about mathematics.

As a way to invite PSTs into the venture of studying mathematics, I surmised that integrating this study with a task they looked forward to, reading books to children, could be worthwhile. If embedding mathematical thinking in children's books "enhances children's understanding of mathematics, promotes their enjoyment of the subject, and develops their conception of mathematics as an integral part of human knowledge" (Griffiths & Clyne, 1991, p. 9), the notion of integrating mathematics and children's literature in my students' experience made sense. I had found this useful in the past when students incorporated existing children's books into their lessons during their mathematics methods course [see Author (2003)]. But I also needed this integration to help me assess the PSTs' mathematical knowledge, in particular, to assess their ability to use mathematical vocabulary and concepts appropriately.

The plan I developed enhances the PSTs' appreciation for the complexity of the mathematics and provides a means for me to assess their ability to use the language and representations of mathematical concepts they study. I ask PSTs to write two letters and a children's book about specific topics studied during the term. (See Figure 1 for a brief description of the book task.) By pairing my PSTs with first graders at a local rural school, the letters and book gain a personal audience.

The term in which the letters and book are assigned is one in which the mathematical content includes the study of statistics, probability, measurement, and geometry,

The story board:

- May take a variety of forms (Note cards, PowerPoint file);
- Includes the plan for each page's focus and content – will it include a picture, stickers, words, etc. and how will content be laid out; and
- Is not a draft of the book in the sense that it must look just like the book, but may be a sketch of the book.

The book:

- Should have at least eight (8) pages, including the notes section,
- May be completed by hand and/or using some form of technology,
- Should be original work,
- Should reflect the age or anticipated eye-hand coordination of the audience, and
- Should foster the development of one or more appropriate geometric concepts for 1st graders.

The notes:

- Should identify the level of geometric understanding at which the use of the book makes the most sense (Need not specify "van Hiele level" as such – rather indicate what is assumed at that level, e.g., "This book can help a child recognize geometric shapes by sight, though the child may not be able to explain why it is called that name.");
- Should indicate what is assumed as attained prior to reading the book (e.g., "The child may not be able to correctly identify shapes by name prior to reading this book.");
- Should describe how the book is to support the development of geometric thinking and expression (Is the book intended to introduce the next level? Is the book useful for practicing a certain concept? Can the book be used easily to assess whether a level has been attained or if vocabulary is appropriately used?);
- Should indicate the Ohio Standard and Indicator(s) addressed in the book,
- Should suggest several questions that the reader might ask during or following the reading of the book to maximize the learning experience for the child; and
- Should include suggestions for related children's books and extension activities (e.g., "When walking around the house, ask the child to identify objects that look like triangles. To help the child develop further, ask the child what makes the shape look like a triangle, but do not be concerned if they are not able to say, 'It has three sides.' Being able to identify a triangle comes before being able to describe its characteristics.").

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Fig 1 Suggestions for storyboard, book, and notes

in this order. The PSTs are assigned a pen pal early in the term, and each is asked to write a letter to their first-grade pen pal that includes an appropriate question that the pen pal can collect data on and report back to the PST. A few weeks later, a second letter is written that includes a probability experiment that the first-grade pen pal is asked to complete with their family. PSTs are encouraged to create tasks for both the statistical question and the probability experiment that are focused and bounded.

As we begin the study of geometry, PSTs begin work on their children's books. They may select any geometry concept as the focus of their book. The critical issues for the story itself are that PSTs must be accurate and clear in their use of vocabulary as well as thoughtful as to the level of difficulty and appropriateness of the content for first graders. The "Notes to the Reader" pages must include a statement of the level of geometric understanding children reading the book should have as they begin their reading, questions that the teacher may ask to deepen children's understanding of the concept, activities to extend the learning, and information about related children's books.

Visiting Pen Pals

Late in the semester, I arrange for the use of vehicles to transport the PSTs to the elementary school where their pen pals attend first grade. With the increase in appreciation and support for service learning in university life, PSTs receive credit for contributing outside the university and the trip to the elementary school receives assistance in the form of vehicles. The proximity of the school enables our visit to be completed within a single two-hour class period.

PSTs are directed to the appropriate classroom to find their pen pal, with pen pals often being in two different classrooms. Each PST wears a self-decorated nametag that includes their names as well as the name of their pen pal. Child and PST pairs move to a location in the classroom where they can exchange greetings and get to know each other a bit before the PST shares the book they have written with the first grader. A gentle hum of activity spreads through the rooms as the PSTs proudly read their books to their pen pals. Questions that were included in the "Notes to the Reader" provide authors with material to ask about, helping the PSTs to see value in the effort they put into creating the "Notes."

When books are completed, the pen pal may show the PST their desk or work around the classroom. The PST is encouraged to ask the first grader about the results of their data collection and probability experiment. If possible, the PST and pen pal carry out the probability experiment together and talk about the results.

The thirty-minute visit goes by quickly and the pen pal pairs say their goodbyes. When we return to campus there is just enough time to hear a few anecdotes before class is over.

Extending Experiences

One semester a first-grade teacher used the pen pal relationship and the letters sent to her students as an opportunity to integrate the first-grade mathematics and language arts curricula. Using the data collection task each PST sent in their first letter, the teacher had her first-grade students create data recording sheets with their pen pal's question on the top (e.g., see Figure 2).

Fig 2 Data recording sheet

The sheets were placed on each student's desk. Then, all class members rotated around the classroom, placing a tally in the appropriate place on their peer's data sheet. After the recording was complete, each child took their data and created a bar graph to display their data. The teacher then had them write a letter to their college pen pal sharing what they found out about

the question. PSTs were able to save these for their future professional portfolios.

Another semester, due to the numbers of PSTs and first graders, one PST was the pen pal for a whole class. This was a very special experience for the PST, resulting in her reading her book to the whole class and receiving a large "Thank You" note signed by all of the children.

Some books have been written using the pen pal as a character in the story. When making the child a part of the story, the child responded warmly and attentively to the PST's creation. For many, this was the first time anyone had prepared something especially for them. PSTs also incorporated manipulatives into their books. Figure 3 shows the cover and a page from a PST's book prepared for her pen pal Adam. The PST cut magnetic rubber sheets into tangram pieces and had her pen pal create various figures that were a part of the story she created about the pen pal's dream.

For many, this was the first time anyone had prepared something espeially for them . . . various figures were created about the pen pal's dream.

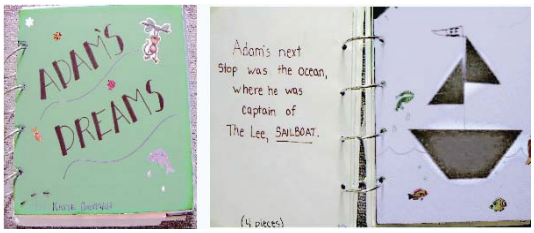


Fig 3 Cover and page from PST book

Learning from the Experience

The PSTs gained important insights into both mathematics and learning mathematics through the writing and sharing processes involved in this project. In addition, I was able to assess their ability to write mathematics accurately and clearly. They shared many experiences in class discussions, relating comments and questions their pen pals shared. These served to both confirm suggestions I had made about children's mathematical thinking and to make the assignment more meaningful for all students. For example, I had suggested that first graders should not be expected to understand the terms "right angle" or "90º." So they might describe a square as a quadrilateral with four sides the same length and four angles the same size. A PST who had not heeded this advice had the following experience. Her book included a description with the term "right angle" and she was delighted when, after reading the book to her pen pal, the child looked around the room and pointed to a figure with a right angle and said, "Oh, look! A right angle." The PST smiled, thrilled that her book had helped the child with that concept. She smiled until the child excitedly added, "Oh, look! There's a left angle." After sharing this experience with her PST-classmates, we had a good discussion about being attentive to the grade-level expectations and vocabulary.

Students discovered the value of multiple representations and tactile qualities. Several used foam shapes or textured objects in their books and found that the children responded very well to these, referring back to them when they used the vocabulary that had been introduced in the books. Books that were colorful but not overly cluttered were seen to attract the children's interest and to provide easier access to the ideas. Figures 4, 5, and 6 show several examples of techniques used by students to enhance their pen pal's experience.

PSTs came to understand that a richer personal meaning for the concepts grew out of their thinking about how to present the content to their pen pal. The expectation

Fig 4 Book enhancement

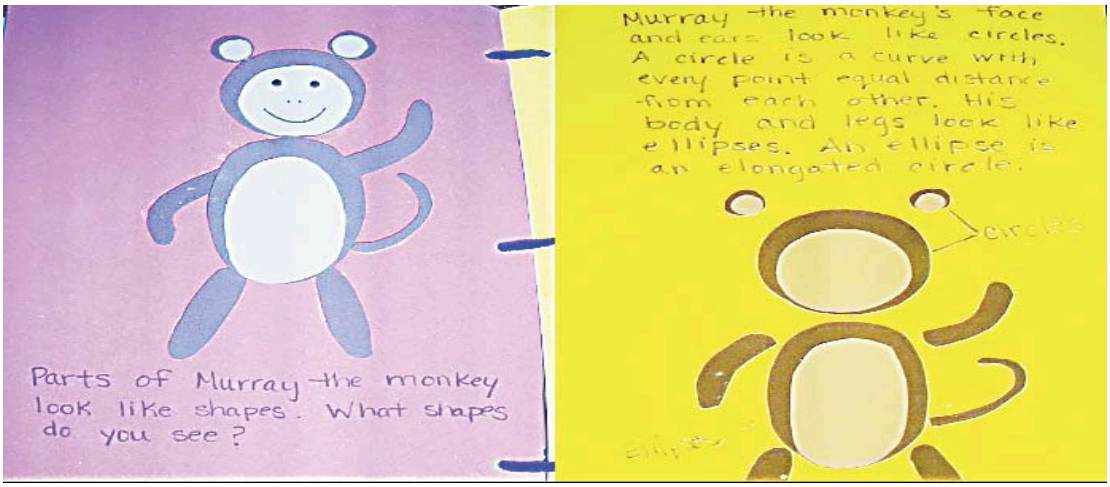


Fig 5 Book enhancement

Fig 6 Book enhancement

that the content of the book would be related to the *Ohio Early Learning – Primary Content Standards for Mathematics* (2008) not only gave the students somewhere to go to determine what to write about, but also made the task more professionally connected to them as prospective teachers. They recognized the value of the "Notes" that they had been required to prepare in the back of their books. In addition, the questions that they had generated to assist the reader helped them to assess the importance of different attributes and issues surrounding a concept. Having questions that required more than a one-word answer were valued for what they told the PSTs about their pen pal's understanding.

Assessing the Learning

The questions and notes were particularly helpful in determining whether the PSTs had developed a clear sense of what the mathematical aspects of the concept they wrote about involved. I also could tell whether students had referred to National or Ohio Standards for guidance. (See Figure 7.) Some students added extension activities that indicated the depth to which they had thought about the concept and how to connect it to the experiences of learners.

One PST created a book of figures made out of specific shapes; for example, in Fig-

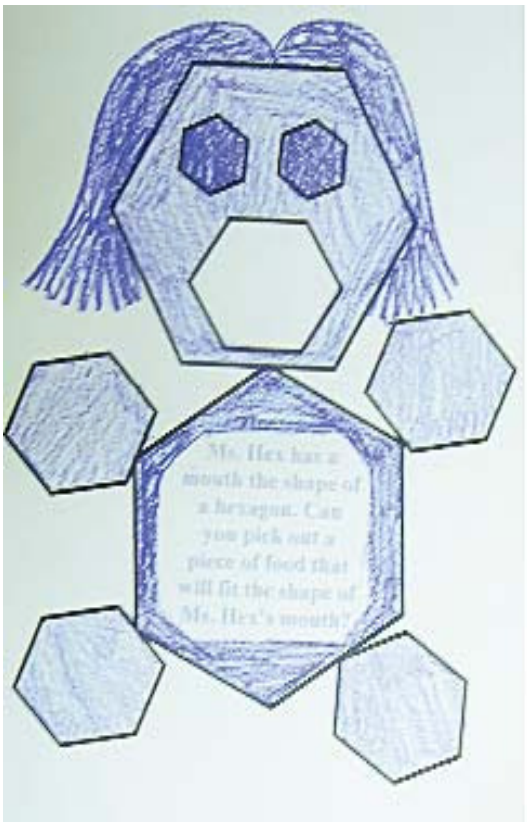
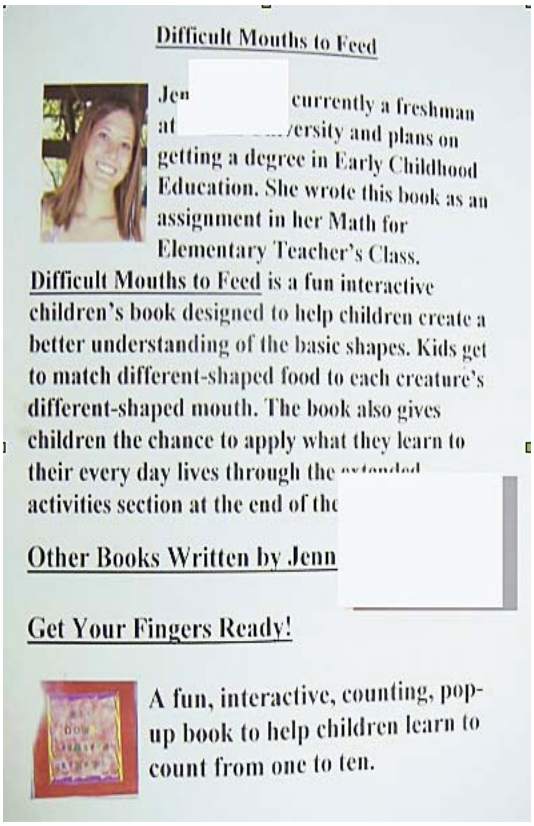


Fig 7 Sample assessment



Difficult Mouths to Feed

Jen currently a freshman at ...versity and plans on getting a degree in Early Childhood Education. She wrote this book as an assignment in her Math for Elementary Teacher's Class.

Difficult Mouths to Feed is a fun interactive children's book designed to help children create a better understanding of the basic shapes. Kids get to match different-shaped food to each creature's different-shaped mouth. The book also gives children the chance to apply what they learn to their every day lives through the extended activities section at the end of the

Other Books Written by Jenn

Get Your Fingers Ready!

A fun, interactive, counting, pop-up book to help children learn to count from one to ten.

Fig 8 Sample assessment

ure 8 we see a figure made out of hexagons. In the "Notes", she included:

"Would these creatures be able to eat each other's snacks? (Possible answer: Mr. Tangle would be able to eat Mr. Box's snacks because a square is also a rectangle.) Would you ever want to have a mouth a certain shape? What would it be? What kind of foods could you eat with a mouth this shape?" Then as an extension the author suggested, "When you are eating a snack/meal next, ask the child to identify what shaped mouth a creature would have to have to eat that certain food." The PST carried her topic throughout the questions and extensions so that they worked together as a piece to give me a sense of her thinking about the figures, their attributes, and their inter-relationships.

Final Thoughts

The most supportive evidence that this project was meaningful for the students and that they felt good about what they had done came at the end of one of the books by a student who had been in an earlier course I teach in which they are expected to create a counting book. The student's final page is shown in Figure 9. What a positive expression of her pride in her work!

The pen pal project provided opportunities for my students to examine content closely, to consider how to represent it, and to create an example of their ability to communicate mathematical ideas. The pen pals and their teachers expressed great satisfaction with the experience. I was able to use the products as a gauge of my students' understanding of a piece of mathematical knowledge needed for teaching. The task engaged the students and created an environment in which they felt comfortable playing with mathematical ideas. Ω

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Think About It!

ASTROCYTES: BUSY LITTLE GLIAL CELLS

"The domain of one astrocyte can cover one hundred thousand synapses. ... astrocytes regulate synapse strength by communicating through their own glial network. This network operates outside the neuronal network, unconstrained by the hardwired lines of connections strung between neurons. New research is beginning to provide evidence that astrocytes do indeed change the strength of their connections in learning."

Fields, R. D. (2009). *The other brain,* 278. Simon & Schuster, NY.

"The human brain, with its 100 billion neurons and countless synaptic connections between them, has been described as the most complicated structure in the universe.

ALSO: Neurons only account for 15% of the cells in the brain. The remaining cells are composed of various forms of glial cells."

Fields, R. D. (2009). *The other brain,* 211, 240. Simon & Schuster, NY.